DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the device which the size of a tip part bundles up to a non-processed board from the original recording which has a minute pattern of 100 nm or less, transfers the pattern of a large area, and performs micro processing (imprint).
[0002]
[Description of the Prior Art]As a method of realizing detailed lithography across the diffraction limit of light, Not the lithography by light or an electron beam but the method called nano imprinting is proposed as processing technology of new nano metric size (J. Vac. Sci. Technol. B14 (1996) 4129). This method the original recording (mold) which has the uneven pattern of 100 nm or less processed by the electron beam, After pushing against the soft resist film which produced the film on the flat substrate, the resist film of the portion pushed in by the heights of the pattern is shaved off by reactive ion etching etc., The minute pattern of the original original recording processed by the electron beam is transferred on other substrates, and the minute pattern which has the original original recording and complementary unevenness is formed by a high throughput.
[0003]In this method, the mold of a press is taken by using resist films, such as PMMA, as a pattern transfer film. For this reason, when the original recording in which the minute pattern was formed is pressed, in order not to make the pattern formation portion of a resist film produce air bubbles etc. by pushing of pattern heights, It is necessary to place some processing devices containing original recording and a processing substrate under decompression or a vacuous condition, and the mechanism which maintains the inside of a device at a vacuum as a result is formed. The plasticity and the mobility of the resist film at the time of a press are secured, and the mechanism which heats and carries out temperature control of the whole processing substrate is formed in order to make transfer from pattern heights easy.
[0004]The following problems are among the conventional microfabrication apparatus and processing methods which were mentioned above.
[0005](1) The device and vacuum devices for performing decompression and heating are

required, and that much excessive cost starts. The high-pressure mechanism which exceeds 100 kg/cm^2 as a press device for processing is required.

[0006](2) Since it is the pattern transfer of the actual size by the press of original recording, a working dimension receives restriction with the process tolerance of the original recording by EB lithography technology etc. Since the pattern which changes with exchange of a mask cannot be transferred in piles like photolithography technology repeatedly, it is difficult to divert to the then conventional IC production technology as it is.

[0007](3) The original recording used for pattern transfer forms an uneven pattern of 100 nm or less in the surface of an upright material which has high hardness with the lithography of EB, and production of original recording takes time to it, and also it requires the material itself and the cost of processing.

[0008]

[Problem(s) to be Solved by the Invention]The purpose of this invention cancels the problem of conventional technology, and there is in providing the large area of one or more mm squares with the simple microfabrication apparatus which can carry out package processing of the detailed pattern with a working dimension of 100 nm or less in low cost.

[0009]

[Means for Solving the Problem]A means by which a microfabrication apparatus of this invention holds original recording in which a minute pattern was formed, and a processing substrate, A means to induce energy transfer or mass transfer between original recording and a substrate, and a means to control a relative position of original recording and a substrate are provided, and a minute pattern is transferred from said original recording to said substrate.

[0010]In this invention, transfer of a pattern by energy transfer or mass transfer between said original recording and said substrate, It is made by a functionality thin film from a local chemical reaction or pattern heights voltage between current from pattern heights to a substrate or an exposure of an electron beam, pattern heights, and a substrate or impression of a magnetic field, and near the contact portion of pattern heights and a substrate face to a substrate face, or movement of particles.

[0011]As for heights of a minute pattern formed in original recording used by this invention, it is preferred that it is radicalized by chemical / mechanical etching, grinding treatment, or alternative deposition of a substance. Si in which a minute pattern which has heights radicalized by anisotropic etching as an example of original recording was formed is mentioned.

[0012]In this invention, a means to exchange two or more original recording which has parallel translation or a minute pattern which makes it rotate or is different to one substrate for one original recording to one substrate as a means to control a relative position of said original recording and a substrate is mentioned.

[0013]

[Embodiment of the Invention]Hereafter, this invention is explained more to details. In this invention, what consists of conductive materials which have the heights pattern of 100 nm or less formed with the lithography using EB the same with using for the "nanoimprint method",

such as metal or a semiconductor, can be used as original recording (mold). Pattern transfer at the time of processing in this invention is performed through the outermost superficial layer of the pattern transfer film formed on the outermost superficial layer of the processing substrate itself, or a processing substrate. For this reason, it is preferred to radicalize the tip part of the heights pattern of original recording especially, by the deposition of an atom and a molecular cluster which used milling processing, a particle beam, etc. beforehand in simple perforation (dot formation) processing, in order to make a working dimension smaller. In order to make a working dimension still smaller, selective growth of the carbon nanotube of a monolayer may be carried out on the heights pattern of original recording.

[0014]It is desirable to use the following especially as a mold used for processing in this invention. That is, it is a mold which has the pattern regularly arranged in the interval and direction with a constant pyramid-like structure of the convex shape which are formed by combining the package pattern formation by photolithography technology, and the anisotropic etching of a Si substrate. By formation of the partial pattern by perforation it is possible to control the tip part of a pyramid by this method in curvature radius of 5 nm or less, and according to forcing of a mold, mass transfer, and voltage impressing. It does not depend on the drawing method using EB etc. which is expensive and requires a long time, but the detailed pattern formation equivalent to the tip diameter of a pyramid far smaller than the pattern size formed by photo lithography from the first becomes possible.

[0015]By countering such a mold and arranging the mask which consists of an insulating material which has a mold from the first and a complementary pattern in the pars basilaris ossis occipitalis or the upper part of the material processed, It is possible to make smaller one-piece pattern size of one piece which increases the effect of the electrode concentration at the time of voltage impressing, and is formed of the alignment of a mold and a mask.

[0016]In order to attain the processing density equivalent to the memory structure of a terabit class to an entire substrate eventually, Since it is necessary to make the processing pitch by the lithography before forming the regular array of pyramid-like structure smaller (20-50 nm), if the following techniques are used even when using the pyramid arraying structure arranged at intervals of the micron order formed by photo lithography although only processing of this portion may be performed with EB art, It is possible to form the pattern of a 20-50-nm pitch in the front face of a substrate eventually.

[0017]That is, it is the method of repeating processing by a stamp and performing it, controlling the horizontal position of a mold using position bubble ****** shown in having existing applied (an alignment method and a processing method, Japanese Patent Application No. 11-261911). For example, when the mold which has the pyramid arraying structure arranged at intervals of 2.4 micrometers is used, it becomes possible to form the minute pattern covering the above-mentioned entire substrate by performing 60x60 processings in a 40-nm pitch.

[0018]The following methods are used as a concrete alignment method of original recording and a processing substrate. First, while holding the original recording in which the pattern was formed, a processing substrate is held and both relative position is controlled by the self alignment (autogenous control of relative position) part formed in specification of both sides in

the part. As this self alignment part, it may be in the relation between a key and a keyhole as a three-dimensional structure. Attraction may be mutually produced according to a physical energy gradient as a horizontal distance increases in both specific contact parts as a self alignment part. For example, the mechanism (self alignment mechanism in which meniscus power was used) in which specification of both sides is made to produce the difference of surface energy by embellishing a contact part chemically is mentioned. Also when transferring a pattern again to the substrate by which the pattern was already transferred by the same method using the original recording which has a temporarily different pattern with such a self alignment mechanism, the relative physical relationship in an entire substrate is guaranteed.

[0019]The following methods can be used in order to raise the accuracy of relative-position control with original recording and a processing substrate even on a nano meter level.

[0020]While holding the original recording in which the pattern was formed, the relative position of original recording and a substrate is controlled by the 1st method by holding a processing substrate and detecting change of the light interference fringe between the tilting tables formed on original recording and a substrate.

[0021]The relative position of original recording and a substrate is controlled by the 2nd method by detecting change of the fluorescence intensity by the distance of the fluorescent substance marked on original recording and a substrate, and a fluorescence-quenching substance. In this case, if the distance of a fluorescent substance and a fluorescence-quenching substance approaches, the optical quenching by energy transfer or an electronic transition will become remarkable. Generally, energy transfer happens, when the fluorescence spectrum of a fluorescent substance laps with the absorption spectrum of a fluorescence-quenching substance. In the case of energy transfer, in the distance between two substances, tens of nm to optical quenching becomes remarkable, and in being an electronic transition, in the distance between two substances, several nanometers to optical quenching becomes remarkable. The fluorescence intensity can also express all and a case with the exponential function of distance. Therefore, the position control which combined the optical quenching by energy transfer and the optical quenching by an electronic transition is also possible. Various organic and inorganic fluorescent substances can be used as a fluorescent substance. For energy transfer, it is preferred to use metal and coloring matter as a fluorescence-quenching substance. For an electronic transition, the organic substance and mineral matter in which ionization potential differs from electron affinity can be used as a fluorescent substance.

[0022]The relative position of original recording and a substrate is controlled by the 3rd method by detecting change of the tunnel current during the minute chip formed on original recording and a substrate, atomic force, or the scattered light.

[0023]In order to control the horizontal relative position between the parts in connection with alignment by the 1st - the 3rd alignment method by nanometer order eventually, It is desirable to carry out position control of either or the both sides of the original recording or processing substrate side according to the position control mechanisms using the piezo-electric element used by STM, AFM, etc.

[0024]the [the self alignment mechanism mentioned above, the 1st -] -- it becomes possible

to realize relative-position control of the NANOMETA accuracy in the whole surface on which the pattern of original recording and a processing substrate is drawn according to the detailed alignment mechanism of three. Specifically, alignment is performed as follows. That is, after the alignment mechanism mentioned above performs relative-position control of original recording and the whole processing substrate surface, relative-position control of a to [from the submicron order between a pattern part and a processing substrate / tens of nm] is performed with the above-mentioned alignment methods 1 and 2. As for these alignment means, forming near the circumference of a pattern part is desirable. In order to raise even a subnano meter level from NANOMETA, the accuracy of still more final pattern transfer, By providing the part for detecting the 3rd above-mentioned tunnel current or atomic force by an alignment method, i.e., STM, and AFM in the center section of a pattern part and a processing substrate, It crosses all over a pattern and it becomes possible from near a pattern center part to guarantee the accuracy of the relative position control between processing substrates on a NANOMETA subnano meter level.

[0025]About processing of the substrate in this invention, the surface of the substrate material itself which is the target of processing may be sufficient as the portion in which a minute pattern is transferred by processing, and the surface of pattern transfer films, such as resist provided on the substrate in order to improve the accuracy and flexibility of processing more, may be sufficient as it.

[0026]In the microfabrication apparatus of this invention, a minute pattern is transferred by local energy transfer or mass transfer between original recording and a substrate. For this reason, a means to induce a precise alignment means and local energy transfer, or mass transfer with the substrate (the pattern transfer film may be formed on it) used as the original recording for processing and a processing object is formed. Processing is performed by the following methods, using such a device.

[0027]First, it fixes in the state where it stuck with the convex shape pattern of original recording, and the processing substrate, by a means to control the relative position of the means and both holding original recording and a processing substrate. These mechanisms should just fix both and do not need to apply a strong pressure like the conventional device. Since it is not necessary to put these mechanisms under decompression, vacuum devices are also unnecessary. Next, in [impress the voltage for inducing electric energy transfer between original recording and a substrate and] contacting parts with a convex shape pattern, a substrate, or a pattern transfer film (for example, resist), By electronic energy (current) or local chemical reaction, an oxide film is made to form by anodization, or the chemical composition of a resist material is changed, and it changes into the structure which is easy to dissolve by an etching process. When pattern transfer films, such as resist, are used, development and an etching process are further performed as post processing, and the patterned target substrate is obtained eventually.

[0028]In this case, in local oxide film formation, the rugged structure of an order of 100 nm or less and the structure where hydrophilicity differs from surface hydrophobicity are acquired. When pattern transfer films, such as resist, are used, the pattern of unevenness by etching is

obtained to arbitrary substrate materials. When a material suitable for record of light, the electrical and electric equipment, magnetism, etc. is used as a high density recording medium more than 1 $Tbit/inch^2$, A recording material should just produce the isolation construction regularly arranged in the pitch of 50 nm or less by making a recording material arrange regularly on a minute pattern, using as a mask the substrate which has the minute pattern obtained by the method mentioned above as it is.

[0029]If local energy induction is used by the above-mentioned mold heights and the voltage impressing between substrates, it is possible to produce local polarization, and for it to be stabilized and to also make the effect of local polarization hold by the structure of micro crystallite from the first and particles to the micro crystallite of a dielectric or the structure of particles for example. It enables this to form a detailed polarization pattern covering the large area of one or more mm squares in the pitch of 100 nm or less. If the mold which similarly consists of a magnetic material (a flat may be sufficient as the tip of a pattern) which patterned unevenness is used, For example, by controlling magnetization of the whole mold by an AC coil, it becomes possible in the pitch of 100 nm or less to transfer the pattern of vertical magnetization with a large area to the substrate face which consists of the micro crystallite and the particles of a magnetic body. Such a structure is used also as the standard pit of the servo control system used for the position control of a read head indispensable when realizing high density recording of a terabit class, and a structure for tracking. If it transfers on a substrate after applying to the heights of a mold the material which has the hydrophobing ability by surface ornamentation of an organic thin film etc. (or local chemical nature is controlled), It is possible to transfer the pattern of hydrophilicity and a canal (or other local chemical nature) on a substrate with a large area. Therefore, an amorphous nature pigment material sensitive to the local hydrophilicity and hydrophobicity of a ground is vapor-deposited, and it becomes possible to form a detailed regular array over an entire substrate.

[0030]As shown above, problem [of conventional technology] (1) - (3) is solved by this invention, migrate to the entire substrate of practical size (one or more mm squares), and are uniform, . The size pitch and the direction gathered thoroughly. It becomes possible to form the minute pattern of the 100-nm or less (20-50 nm is possible) pitch reflecting the thin film forming by the local pattern transfer by perforation and resist exposure, the electrical and electric equipment and a magnetic property, and mass transfer on condition of a high throughput and low cost.

[0031]

[Example]Hereafter, an example explains this invention still in detail.

(Example 1) The composition of the microfabrication apparatus used by this example is shown in drawing 1. The minute pattern 12 is formed in the original recording (mold) 11 used for processing in the pitch of 100 nm or less of the convex shape, and this original recording 11 is held by the original recording holder 13. On the other hand, the pattern transfer film 22 is produced on the processing substrate 21, and this substrate 21 is held by the substrate holder 31. The substrate holder 31 is laid on the moving actuator 32 precisely driven to X, Y, and a Z direction, the moving actuator 32 is laid on the coarse adjustment actuator 33 roughly driven to

X, Y, and a Z direction, and the relative position of the original recording 11 and the substrate 21 is controlled by these mechanisms. Between the original recording 11 and the processing substrate 21, voltage is impressed from the voltage control system 41. The moving actuator 32 and the coarse adjustment actuator 33 are controlled by the drive control system 42. Although drawing 1 shows these control systems independently, a feedback loop may be formed in order to maintain the voltage between original recording and a substrate, and the signal of current at constant value depending on the control method at the time of processing, for example.

[0032]The structure of the original recording used by this example is shown in drawing 2. Drawing 2 (a) is a top view and drawing 2 (b) is a sectional view. As shown in drawing 2, the pattern which the heights 12a of the diameter of 20 nm arranged regularly in a 50-nm pitch is formed in this original recording 11.

[0033]The original recording 11 shown in the substrate 21 which applied PMMA resist as the pattern transfer film 22, and drawing 2 was installed in the microfabrication apparatus shown in drawing 1, and both were stuck to it. Voltage suitable between the original recording 11 and the substrate 21 was impressed by the voltage control system 41, and the perforating process of the PMMA resist surface was crossed all over the substrate 11 and performed collectively.

[0034]When the surface after processing was observed by AMF, corresponding to the field (1 cm x 1 cm) in which the pattern of original recording was formed, the structure which the hole where the diameter of about 20 nm is round arranged regularly at intervals of 50 nm was observed. The perforation portion of the PMMA resist film was selectively filled up with the dye molecule by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 2-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 50-nm pitch was acquired. Since this dye molecule has good etching resistance, it is also possible to transfer a pattern by using this structure as a mask further into the material which constitutes the substrate of a ground.

[0035]Next, the detailed SiO_2 pattern was collectively crossed all over the substrate and formed by local anodization on the surface of a Si substrate using the same original recording. In this case, in order to form a smaller pattern, it is desirable to radicalize the minute pattern heights of original recording further with the selective growth which used the beam of etching, grinding treatment, and a corpuscular beam, etc. By control of the moving actuator, after sticking the heights of original recording on the Si-substrate surface, for 1 ms, the pulse voltage of -10V was impressed to the original recording side, and processing by local anodization was performed only to the portion stuck to the minute pattern of the convex shape.

[0036]After processing it, when the surface was observed by AFM, corresponding to the field (1 cm x 1 cm) in which the pattern of original recording was formed, the structure which SiO_2 which rose to mountain shape arranged regularly at the interval which is 50 nm was observed.

This method is applicable to any metal and semiconductors, if an oxide film is formed by anodization.

[0037]Next, using Si which has conductivity as original recording, the pattern of heights was formed by anisotropic etching, the carbon nanotube was selectively grown up at the tip of pattern heights with the CVD method, and it was radicalized. By TEM observation, the curvature radius at the tip of pattern heights was estimated at 1 nm or less. Hydrophobing processing of the surface of the Si substrate used as a processing object was beforehand carried out by the silane coupling agent. After sticking the heights of the radicalized original recording on the Si-substrate surface by control of a moving actuator, for 1 ms, the pulse voltage of -10V was impressed to the original recording side, and processing by local anodization was performed only to the portion stuck to the minute pattern of the convex shape. This processing is equivalent to forming a hydrophilicity SiO_2 field in the substrate face by which hydrophobing was carried out.

[0038]After processing it, when the surface was observed by AFM, the structure which SiO_2 which has the diameter of 10 nm or less which rose to mountain shape arranged regularly at the interval which is 50 nm was observed. When surface local chemical nature was investigated by LFM (friction force microscope) etc., it was checked that the field of detailed hydrophilic nature is formed in a 50-nm pitch on a hydrophobic substrate. The dye molecule condensed selectively to the SiO_2 field by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 1 nm of thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 50-nm pitch was acquired. Since this dye molecule has good etching resistance, it is also possible to transfer a pattern by using this structure as a mask further into the material which constitutes the substrate of a ground.

[0039](Example 2) The structure of the original recording used by this example is shown in drawing 3. Drawing 3 (a) is a top view and drawing 3 (b) is a sectional view. As shown in drawing 3, the pattern which the crevice 12b of a 20-nm angle arranged regularly in a 50-nm pitch is formed in this original recording 11, and the organic thin film 51 which has hydrophobing ability is applied to the surface of the other heights 12a. When specific metal, such as gold, is formed in the silane coupling agent which has a hydrophobic group at the end as an organic thin film used here in processing the Si-substrate surface, and the substrate face, the hydrophobing agent which has the unity over specific metal, such as thiols, is mentioned. Since it is the purpose to carry out hydrophobing only of the transfer face of a pattern here, not an independent organic thin film but the thing which covered all the surfaces of detailed particles, such as metal particles, by the hydrophobing agent, for example may be produced.

[0040]The pattern was transferred by sticking the original recording which has a minute pattern shown in drawing 3 to Si base top using the microfabrication apparatus shown in drawing 1, and moving an organic thin film. As a result, the structure where hydrophobing only of the field

corresponding to the heights of a pattern was carried out was formed, and the field of the square of a 20-nm angle and a 50-nm pitch was left as a field which has hydrophilic nature.
[0041]When the surface after processing is observed by force mapping (distribution measurement of adhesion force) using LFM (friction force microscope) and AFM, it corresponds to the field (1 cm x 1 cm) in which the pattern of original recording was formed, The image which the portion with a round diameter of 20 nm frictional force and adhesion force indicate the minimum to be (it means that the surface is hydrophilic nature) arranged regularly in a 50-nm pitch was acquired. The dye molecule condensed selectively to the hydrophilic region by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 2-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 50-nm pitch was acquired.
[0042](Example 3) To the substrate with which dielectric materials were formed in the surface as a recording layer, corresponding to the heights of the minute pattern of a mold, voltage is impressed only to the specific region of a recording layer, and the example which controls direction of the charge polarization of the field is explained. By this, the pattern formation equivalent to a record pitch becomes possible about the magneto-optical recording material etc. which have specific dielectric characteristics.
[0043]A conductive mold is specifically stuck to the recording layer which consists of dielectric materials on the surface of a processing substrate using the position control mechanisms in the microfabrication apparatus of drawing 1, voltage is impressed from a voltage control system, and the minute pattern by which direction of charge polarization was controlled in the recording layer corresponding to the heights of a mold is formed. As a recording layer which consists of dielectric materials, in order to make a pattern hold stably, a particle-like thing, the thing which has amorphous nature, or the thing which has the nano crystal structure which advanced crystallization only in the detailed field is desirable. In [after forming the pattern of charge polarization in the surface of the recording layer which consists of dielectric materials by this method, when the potential distribution of the substrate face was observed according to SMM (scanning maxwell stress microscope)] the field of a 1-cm angle, The scanning image which the field where potential is high (low) has arranged in a 50-nm pitch was acquired.
[0044](Example 4) The example which controls magnetization of a mold by an AC coil etc. to the substrate with which the magnetic material was formed in the surface as a recording layer, and controls direction of magnetization of the specific region of a recording layer corresponding to the heights of the minute pattern of a mold is explained. By this, the pattern formation equivalent to a record pitch becomes possible about a magnetic recording material or magneto-optical recording material.
[0045]The microfabrication apparatus used by this example is shown in drawing 4. The microfabrication apparatus of drawing 4 has the same composition as the device of drawing 1, except that AC coil 14 is formed in the original recording holder 12.
[0046]The position control mechanisms in the microfabrication apparatus of drawing 4 are

specifically used, The mold which consists of magnetic materials is stuck to the recording layer which consists of a magnetic material on the surface of a processing substrate, it energizes in the coil 14, and direction of magnetization forms the minute pattern controlled locally into a recording layer corresponding to the heights of a mold. As a recording layer which consists of magnetic materials, in order to make a pattern hold stably, a particle-like thing, the thing which has amorphous nature, or the thing which has the nano crystal structure which advanced crystallization only in the detailed field is desirable. After forming the pattern of local magnetization in the surface of the recording layer which consists of magnetic materials by this method, when the magnetization distribution of the substrate face was observed by MFM (magnetic force microscope), in the field of a 1-cm angle, the scanning image which the field where magnetic force is large (small) has arranged in a 50-nm pitch was acquired. Here, the size of magnetic force corresponds to the size of magnetization as it is.

[0047](Example 5) The microfabrication apparatus used by this example is shown in drawing 5. The microfabrication apparatus of drawing 5 has the same composition as the device of drawing 1, except that the relative alignment (self alignment) mechanism 15 of the original recording 11 and the processing substrate 21 is formed. The details of alignment (self alignment) are as having described above.

[0048]The structure of the original recording used by this example is shown in drawing 6. Drawing 6 (a) is a top view and drawing 6 (b) is a sectional view. This original recording 11 is a product made from metal (nickel), and the pattern which the heights 12a of the shape of a pyramid whose one side of a base is 1.2 micrometers arranged regularly in a 2.4-micrometer pitch by photo lithography and anisotropic etching is formed.

[0049]Using the original recording 11 of drawing 6, by the same method as Example 1, voltage suitable between the original recording 11 and the substrate 21 with which PMMA resist was formed was impressed, and the perforating process of the PMMA resist surface was performed.

[0050]In this example, after one perforating process, parallel translation of every 40 nm of the molds was carried out further horizontally, and the same processing was repeated over a total of 60x60 places. When the surface after processing was observed by AMF, it migrated to the field (1 cm x 1 cm), and the structure which the hole where the diameter of about 20 nm is round arranged regularly at intervals of 40 nm was observed. The perforation portion of the PMMA resist film was selectively filled up with the dye molecule by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 1.5-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 40-nm pitch was acquired.

[0051]Next, the detailed SiO_2 pattern (pattern of a hydrophilic region) by anodization was formed in the Si-substrate surface which performed hydrophobing processing by the same technique as Example 1 using the original recording which has the same structure as drawing 6. In this case, a carbon nanotube is selectively grown up at the tip of the pyramid portion of Si

mold which has conductivity with a CVD method, and the original recording which performed radicalization processing is used for it. By TEM observation, the curvature radius at the tip of pattern heights was estimated at 1 nm or less. After sticking the heights of the radicalized original recording on the Si-substrate surface by control of a moving actuator, for 1 ms, the pulse voltage of -10V was impressed to the original recording side, and processing by local anodization was performed only to the portion stuck to the minute pattern of the convex shape. Also in this case, after one processing, parallel translation of every 40 nm of the molds was carried out further horizontally, and the same processing was repeated over a total of 60x60 places.

[0052]After processing it, when the surface was observed by AFM, the structure which SiO_2 which rose to mountain shape arranged regularly in the field (1 cm x 1 cm) at the interval which is 40 nm was observed. By AMF observation, the path of SiO_2 which rose to this mountain shape estimated that it was 10 nm or less. The dye molecule condensed selectively to the SiO_2 field of hydrophilic nature by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 0.5 nm of thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 40-nm pitch was acquired.

[0053](Example 6) A minute pattern can be transferred using the same mold as Example 5 by the organic thin film and metal particles which have hydrophobing ability by the method shown in Example 2. In this case, what is necessary is just to coat the molecule which dips the solvent containing the molecule which has hydrophobing ability for the tip of the heights of the pyramidal structure formed in the mold surface, or has hydrophobing ability on the surface of a mold.

[0054]The structure of the original recording used by this example is shown in drawing 7. Drawing 7 (a) is a top view and drawing 7 (b) is a sectional view. This original recording 11 performs micro processing by photo lithography to a Si substrate, and after one side of a base forms the pattern which the heights of the shape of a pyramid which is 1.2 micrometers arranged regularly in a 2.4-micrometer pitch, it carries out the opening of the tip of heights. The minute pattern of a hydrophilic region and a hydrophobic region can be efficiently formed by performing repeated pattern transfer, filling up the opening of this "funnel type" with the organic materials or the particles which have hydrophobing ability, and controlling the relative position of a mold and a processing substrate. Under the present circumstances, pattern formation can be continuously performed by supplying material from the upper surface of a mold if needed.

[0055]By this method, the line and space structure of a 50-nm pitch was formed with the line width of 30 nm over the field (2.4 micrometers x 2.4 micrometers). It intersected perpendicularly with this line and space structure, and the same structure was formed. In this way, the regular minute pattern in which the hydrophilic region of the diameter of about 20 nm was left in a 50-nm pitch is formed in a field (1 cm x 1 cm).

[0056]The place which observed the surface after processing by force mapping (distribution

measurement of adhesion force) using LFM (friction force microscope) and AFM, It migrated to the field (1 cm x 1 cm), and the image which the portion with a round diameter of about 20 nm frictional force and adhesion force indicate the minimum to be (it means that the surface is hydrophilic nature) arranged regularly in a 50-nm pitch was acquired. The dye molecule condensed selectively to the hydrophilic region by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 2-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible in a field (1 cm x 1 cm) arranged regularly in a 50-nm pitch was acquired.

[0057](Example 7) The composition of the microfabrication apparatus used by this example is shown in drawing 8. Drawing 8 (a) is a top view and drawing 8 (b) is a sectional view. In drawing 8, the mold 61 forms the heights on the pyramid regularly arranged by the anisotropic etching of Si the same with having been shown in drawing 6, and has a size of an about 1-cm angle. This mold 61 has heights of a 1.6×10^7 (4000x4000) individual. Although omitted by a diagram, the mold 61 is supported by slider head structure for improvement in reservation of the adhesion to the substrate of a mold, and processing speed. To the radial direction (or tangential direction of the circumference) of the disk-like processing substrate 21, each neighborhood of the mold 61 shifts an angle a little, and is arranged. The processing substrate 21 rotates by the spindle motor 62, and the relative position of the mold 61 and the substrate 62 is controlled. The processing substrate 21 is a Si substrate of 2.5 inch diameters, and PMMA resist is applied to the surface as the pattern transfer film 22.

[0058]It fixes to the substrate 21 in the place to which the mold 61 carried in the slider was made to approach slowly, and was stuck. Then, with the same technique, the pulse voltage of -10V was impressed for 1 ms between the mold and the substrate, and the perforating process of the PMMA resist surface was performed as Example 1 showed. After performing one processing, the spindle motor 62 was rotated so that about 50 nm of relative positions between a mold and a substrate might move, and the perforating process was again repeated by the same technique. Under the present circumstances, the position control of the height direction between a mold and a substrate performs a deed and movement of a relative position only by horizontal passing <a thing> on control only by support of a slider head. By such a method, the perforating process of a 60-nm pitch was performed to about 1 appearance all over the substrate of 2.5 inch diameters at high speed. The floor to floor time of the front face of a substrate by this method was about 1 hour. This is equivalent to writing in information at the high speed of no less than 16 gigabits/s, when one hole is transposed to 1 bit of information.

[0059]When the surface after processing was observed by AMF, the structure which the hole where the diameter of about 20 nm is round arranged regularly at intervals of 60 nm over the whole surface of Si disk was observed. The perforation portion of the PMMA resist film was selectively filled up with the dye molecule by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 2.5-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, it crossed all over Si disk and the

structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible arranged regularly in a 60-nm pitch was acquired.

[0060]Next, the detailed SiO_2 pattern (pattern of a hydrophilic region) was formed in the surface of Si disk all over the by anodization of Si disk surface which performed hydrophobing processing, without applying a resist film. In this case, in order to form a smaller pattern, it is desirable to radicalize the minute pattern heights of original recording further with the selective growth which used the beam of etching, grinding treatment, and a corpuscular beam, etc. After sticking the heights of original recording to Si disk surface, for 1 ms, the pulse voltage of -10V was impressed to the original recording side, and processing by local anodization was performed only to the portion stuck to the minute pattern of the convex shape.

[0061]After processing it, when the surface was observed by AFM, it crossed all over Si disk and the structure which SiO_2 which rose to mountain shape arranged regularly at the interval which is 60 nm was observed. The SiO_2 field of hydrophilic nature was made to condense a dye molecule selectively by producing the amorphous nature dye molecule which besides consists of triphenylamine derivatives by 2.5-nm thickness, and performing 120 ** and annealing treatment for 2 minutes. In this way, it crossed all over Si disk and the structure of the separation medium which the dot of the dye molecule in which the record writing by light and an electric charge is possible arranged regularly in a 60-nm pitch was acquired.

[0062]. By this invention, require (1) decompression and the heating machine style which became clear in conventional technology. (2) Restriction of the pattern dimension by the process tolerance of original recording, and restriction of the rework by the defect of an alignment means, (3) Problems, such as floor to floor time, cost, etc. of original recording, are solved, and migrate to the entire substrate of practical size (one or more mm squares), . It was uniform and the size pitch and the direction gathered thoroughly. It becomes possible to form the minute pattern of the 100-nm or less (20-50 nm is possible) pitch reflecting the thin film forming by the local pattern transfer by perforation and resist exposure, the electrical and electric equipment and a magnetic property, and mass transfer on condition of a high throughput and low cost.

[0063]

[Effect of the Invention]By inducing energy transfer or mass transfer local between the original recording which has a detailed convex shape pattern, a processing substrate, or a pattern transfer film if the microfabrication apparatus of this invention is used as explained above, As compared with the imprint art of having the conventional mechanical pressing machine style, transfer of a fine structure pattern of 100 nm or less is attained by easier composition. Under the present circumstances, various processing principles according to the kind and processing method of the substrate, such as local anodization on current and electron beam irradiation, and the surface of a processing substrate, are applicable between pattern heights and a substrate. Therefore, package processing of a minute pattern with a working dimension of 100 nm or less is realized by the processed surface product of one or more mm squares, and the

processing technology of a high throughput and low cost can be provided. The recording-medium structure of having the storage density more than 1 Tbit/inch^2 is producible by using this art.

[Translation done.]